

Quick Processed Bright Displays by Xerography ("PROX I")

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Quick Processed Bright Displays by Xerography

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A family of methods is presented for creating bright displays in seconds by means of xerography. The displays are characterized by high brightness, good definition, and good contrast. In one such system, a cathode-ray tube image is projected onto a charged xerographic plate to create the latent electrostatic image. The plate is then developed with a charged powder and instantly illuminated with a focused beam of light which is specularly reflected at high efficiency from the plate surface and imaged by a lens to create the display. This has been called PROXI, for "Projection by Reflection Optics of Xerographic Images."

When the image is no longer needed, the powder can be brushed from the plate so that the latter is ready for re-use many times, or it can be transferred, as in commercial xerographic copying, to a sheet of paper for record purposes. The system is most suitable to console-type displays. In other proposed xerographic systems the powder image is transferred prior to projection in order to achieve final luminous flux levels suitable for large screen displays.

The projection of an optical image onto a screen, whether as a still or a motion picture, has long been a means of audience entertainment. More recently, the art has been called upon to assume the even more responsible role of educating for information and enlightenment.

The growth in the use of projected visual materials has been possible largely because of readily available photographic techniques, cameras, transparencies, and films. The use of opaque materials in projection systems, on the other hand, has been limited to a few applications in education and business, because such subjects do not conveniently lend themselves to large bright display. Pictures on paper have, therefore, remained materials for personal direct viewing, while transparencies and films have become the media for mass communication.

Despite the wide use of photography in creating visual displays, there are many instances where it leaves much to be desired. For example, when the time lapse between data input, in the form of exposure to a light image, and projection of the recorded information to a screen must of necessity be very short—perhaps 1 to 2 sec or less—then the photographic process becomes complicated and expensive. Quick displays of electronic data can, of course, be made by television and direct-view storage tube systems, but the ultimate screen size and brightness of the display are severely restricted.

With the advent of supersonic aircraft and missiles, military systems require new techniques for high-speed data collection and display. Some of these methods involve projecting visual data of many types onto a screen which can be viewed by planning personnel. The information may be stored in tables or charts, or in electronic computers, and the data

must be processed rapidly and projected onto a screen for viewing.

Similar applications may well exist in the business world. The executive who wishes to review data contained in a filed document, so that a decision can be made, would welcome a fast, efficient, and low-cost system for data retrieval and presentation.

Through newly devised techniques, the xerographic process has been adapted to produce a bright display of input data in the form of an optical image. Of prime importance is the fact that the time lapse between exposure and projection can be as short as 1 sec or less.

The Xerographic Process

Xerography is a photoreproduction process based on physical rather than chemical phenomena.¹ A re-usable photoconductor which is not damaged by exposure to light, radioactivity, or ionizing radiation is first sensitized to light by depositing an electrical charge uniformly on its surface in darkness. Exposure to a light pattern, either by contact or projection, then reduces the original charge at any point in proportion to the light intensity, thereby forming a latent electrostatic image. Development to yield a visible image is accomplished by various methods of dusting the electrostatic image with charged powder particles. Once formed, the powder image can be used for projection directly from the plate surface, or transferred to another surface for remote projection, or transferred to paper for use as "hard copy." The photoconductor can be cleaned and re-used thousands of times, giving a very low operating cost for consumable supplies. Figure 1 reviews schematically the step-by-step creation of a xerographic image.

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1. J. H. Dessauer, G. R. Mott and H. Bogdonoff, *Phot. Eng.*, **6**: 250 (1955).

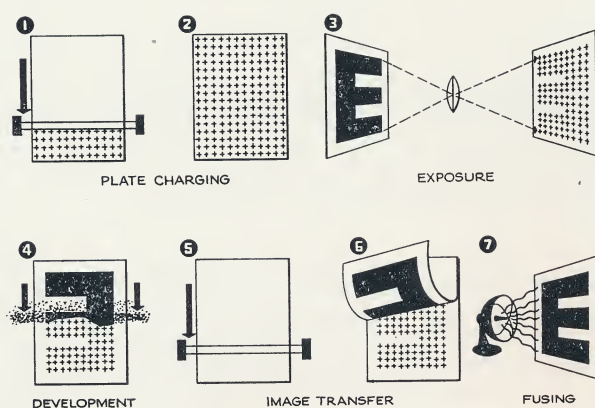


Fig. 1. Schematic representation of the basic xerographic processing steps.

Xerographic Processes for Bright Display

PROXI System

A new type of projection system has been devised, called PROXI, a coined name for "Projection by Reflection Optics of Xerographic Images." In this process, a charged xerographic plate is exposed to optical information, then rapidly developed to produce a powder image which is suitable for bright display without the need for further processing of any kind. The speed of xerographic development and the elimination of all extra steps combine to give PROXI techniques simplicity and access times of less than 1 sec.

In addition to very fast access, the displayed information is nonvolatile, i.e., it is not lost in the event of power failure or equipment breakdown. Screen brightness can be very high, as much as 100 ft-L in some cases, in addition to high image contrast and definition. The processed data can be transferred to paper or other supports for permanent storage, if this is desired; otherwise a purely visual display can be produced. Finally, color can be added to the display by several methods.

The Optical System

The PROXI optical system, shown schematically in Fig. 2, makes use of the surface reflectivity of a xerographic plate. A convergent beam of light is produced by the condensing system and, after specular reflection from the plate surface, is brought to a focus at the position of the objective lens. Thus all the light reflected from the plate is collected by the optics. The xerographic plate serves not only as a mirror to "fold" the optical system, but contains a powder image representing the information to be projected. Light scattered and absorbed by the powder is lost from the optical system and thus, when an image of the plate surface is focused on the screen, the powder areas appear as black on white. It is significant to note that this opaque projection system gives a high efficiency more comparable to that of a transparency projector than to the low efficiency of an ordinary opaque projector,

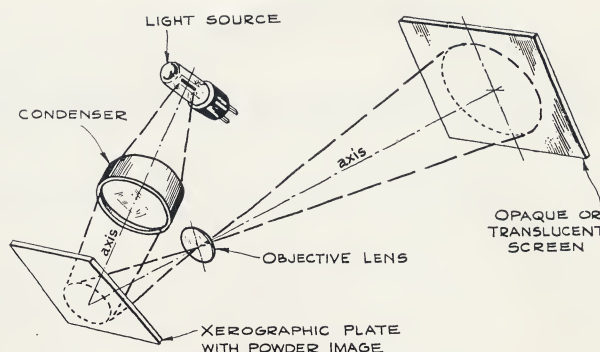


Fig. 2. The PROXI optical system.

despite the fact that the reflectivity of an amorphous selenium plate is only 27%. This difference is a direct consequence of the fact that the light is collected effectively through specular reflection rather than ineffectively through scattering by a nonspecular surface.

Table I summarizes the relative brightness of familiar surfaces seen by opaque projection, using an optical system of the type shown schematically in Fig. 2.

In the test system, the surface sample was illuminated and viewed in directions making an angle of 17° with its normal. The objective was an $f/4.5$ lens, 7-in. focal length, set to produce a magnification of $5\times$ on the screen. The relative brightnesses were obtained as direct measurements of the screen illumination in each case. The incident light represented a beam of $f/3$, while the detector measured essentially only the normal component of the flux reaching the focal plane.

TABLE I
Relative Brightness of Surfaces

Material	Relative brightness
Polished aluminum	100
Selenium	30.5
Ferrotyped photographic paper (unexposed, flat mounted)	5.0
Semimatte photographic paper (unexposed, flat mounted)	3.0
White bond paper (flat mounted)	2.5

It is significant to observe the great loss of brightness for the nonspecular surfaces.

In addition to giving high brightness, the PROXI system can provide images of excellent contrast. The light scattering and absorbing properties of fine powders in the PROXI system are best illustrated by comparing the photographic densities produced by identical powder images viewed in three different ways: by PROXI from a selenium plate, by transmission through a transparency, and by reflection from an opaque paper surface.

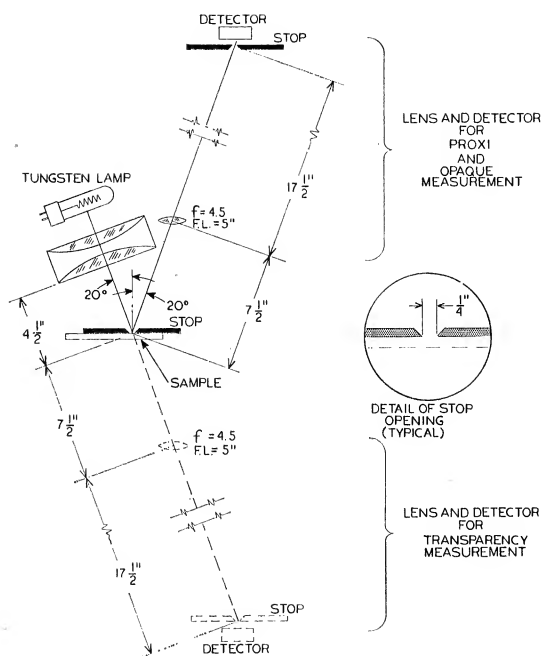


Fig. 3. Optical system for density comparison.

A xerographic plate was exposed to a gray scale and developed by powder cloud methods so that each step contained a different quantity of powder per unit area. This image was then observed in a PROXI system and the brightness ratios measured, thus giving the relative densities of the projected display. Subsequently, the powder from half the plate was completely transferred to a transparency and the other half to gelatin-coated paper. All three samples were measured, using the same optical system as shown in Fig. 3. For the PROXI and opaque samples, the upper configuration, involving reflection, was used; for the transparent sample, the lower "in-line" configuration was used. In each

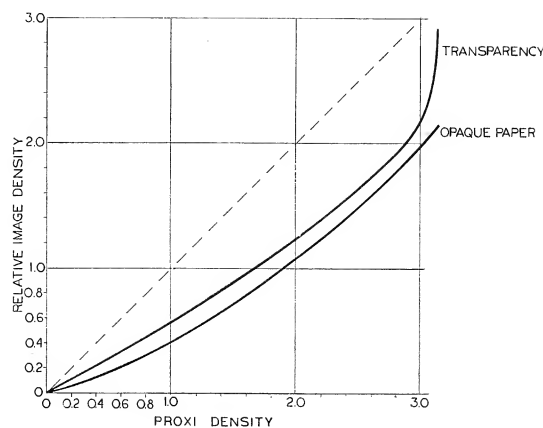


Fig. 4. Powder density vs. observation method.

case, the relative densities of the bare selenium plate, the untransferred paper, and the untransferred transparency samples were measured. The results of the test are summarized in Fig. 4 which indicates the superiority of PROXI over both the transparency and the opaque systems.

Types of Display Mechanisms

Depending on the type of information furnished to the xerographic recorder-reproducer system and the processing methods used, the display may consist of black lines and characters on a bright background, bright lines and characters on a dark background, or continuous-tone pictures. Colored lines and characters on a black background may be obtained by adding color filters to the projection system which is displaying the white-on-black information. Several colors can be shown simultaneously by using as many separate projectors as the number of colors desired.

The system can be adapted to produce a bright display of stationary or moving images derived

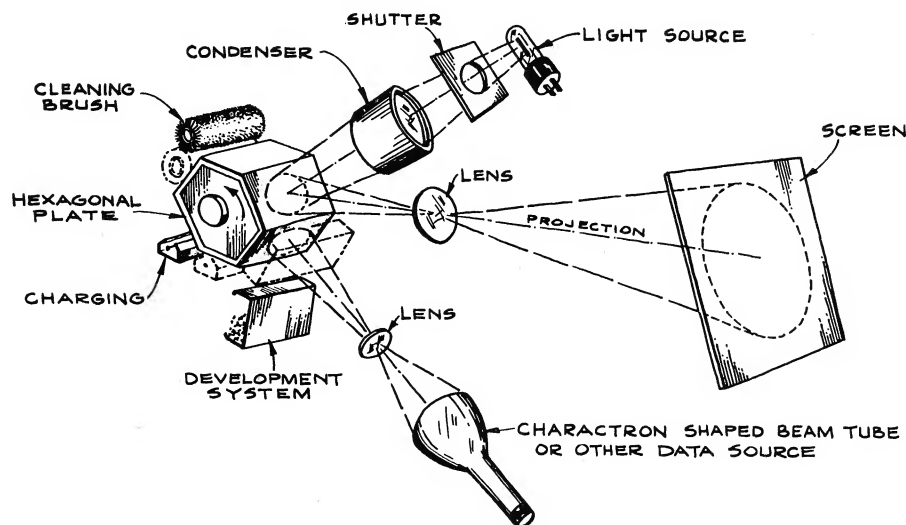


Fig. 5. Intermittent full-frame system.

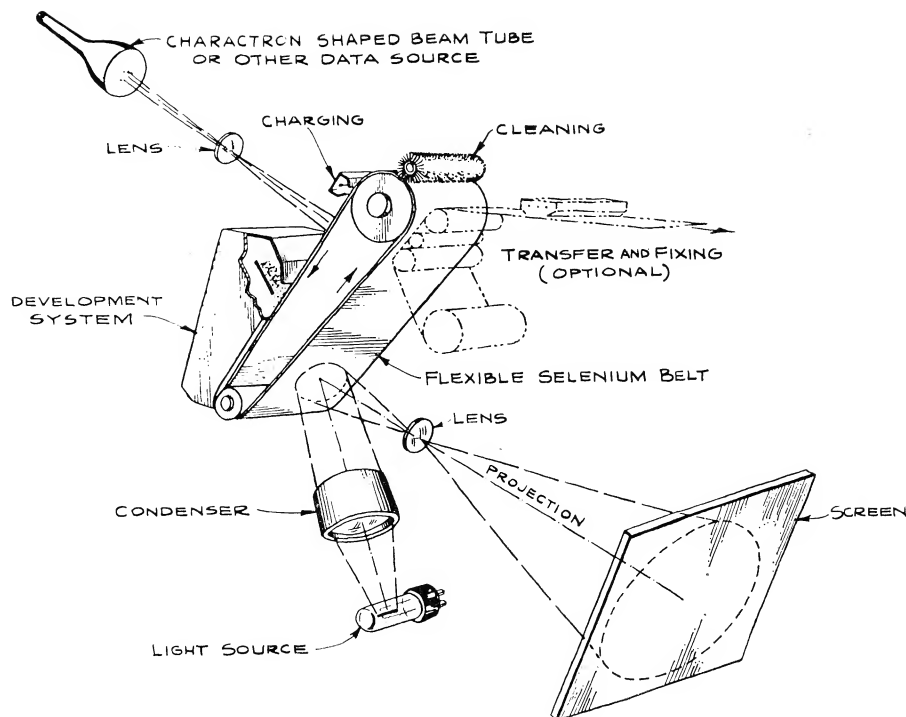


Fig. 6. Continuous projection system.

from optical inputs which are either stationary or moving.

To indicate the variety of PROXI bright display systems which are possible, several representative types are described briefly below.

Intermittent Full-Frame System

Figure 5 suggests a system adapted to record and display a full frame of information such as PPI radar scan, a full-page computer readout, tabular data, a photograph, or a real-life scene, while the

plate is stationary. Selenium plates are mounted on the faces of a polygonal "drum" which can be indexed rapidly from one position to the next by a Geneva movement or equivalent mechanism. While stationary, a charging unit sensitizes the lower face; then the "drum" is rotated to the exposure position where the frame of data is "read in" from a cathode-ray tube, optical projector, or camera. When exposure is complete, the image is developed and the "drum" is turned to the projection station, replacing the previously processed image.

After viewing, the image may be transferred to paper for a permanent record. On the next cycle, the residual image is brushed from the plate, preparing it for re-use.

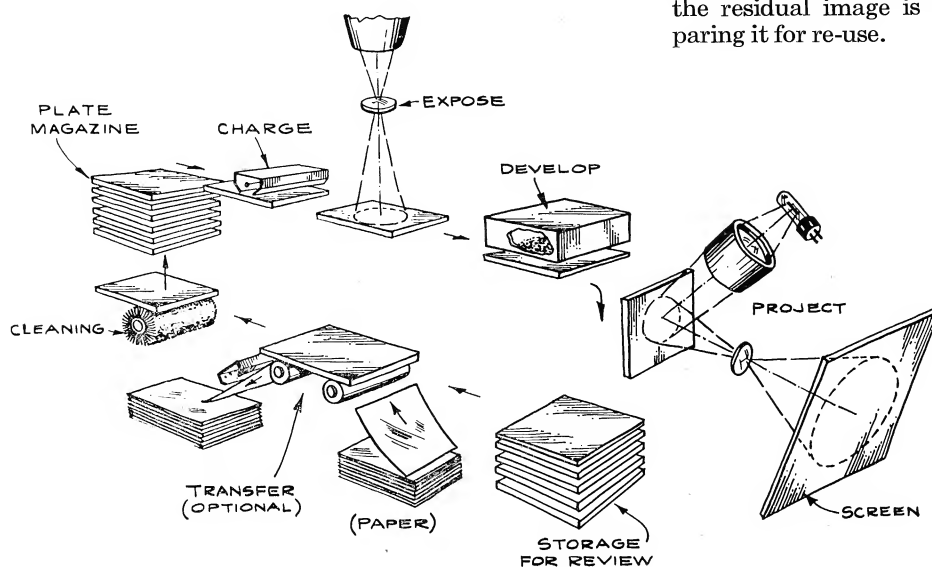


Fig. 7. Magazine system.

Continuous Projection System

The device shown in Fig. 6 is a practical approach to the problem of recording and displaying information being received on a line-by-line basis. This includes teletype, facsimile, side-looking radar, communications monitoring, and others.

The "heart" of the machine is a flexible photoconductor belt prepared by coating selenium onto thin metal or plastic material having a conductive surface. The selenium surface moves continuously past the charging station to the exposure position where a cathode-ray tube or other source "reads in" the information line by line. After development, the image moves across the screen, which is large enough to make many lines visible at a time. The operator reads or interprets the display as it moves, and upon his demand a paper "hard copy" can be prepared for future reference or further study. The cleaning operation prepares the plate for re-use and the process is complete.

Magazine System

The arrangement shown in Fig. 7 permits a greater flexibility in the exposure and viewing conditions than either of the previous systems. Separate flat plates are stored in a magazine and can be handled independently by the mechanism. A plate is first automatically fed out past the charging grid to the exposure station. If a full-frame exposure is to be made, the plate can be stopped in the proper position while the data are "written in" optically. For slit exposure, on the other hand, the plate can be moved across the field continuously. After exposure, the plate is developed and fed to the viewing station for inspection as long as desired. Plates can then be stored for possible review or fed to a transfer station for "hard copy" preparation, and finally on to be cleaned and returned to the magazine.

Applications

The PROXI bright display technique, especially in the form of a direct-view console, is applicable to many types of information-handling systems.

Although commercial applications have not yet been established, several very promising possibilities exist. Some of these have been mentioned in the earlier discussion of display mechanisms, and can be summarized as follows: A full-frame stationary display can be made of data presented on a cathode-ray tube serving as the output of any system such as PPI radar, slow scan TV, closed circuit TV, computer output or facsimile. The PROXI system can also receive optical images from cameras recording documents or real-life scenes. Continuously moving displays can be made of very long or strip-type inputs from side-looking radar, teletype, or facsimile, using a cathode-ray tube to provide the optical image. Applications such as these include reconnaissance, air traffic control, communications, and data storage-retrieval systems.

The PROXI system and its applications, as described, make use of the fact that the developed xerographic plate can serve as the input for a bright display projection system. In addition, and of basic importance, it represents an extremely compact and inexpensive storage of information. Information presented to a xerographic plate by a communication system need be "read in" only once, in contrast with the repetitive scanning of conventional television, then is held in a directly usable form. In multiple distribution systems, particularly those using a central storage facility, this buffering capability will enable wide bandwidth communication channels to be used at high efficiency. Following display, a developed xerographic plate can be stored for a period as long as desired, then removed from storage for review on demand. If long-term storage is necessary, the powder image may be transferred to paper and fixed, giving a permanent "hard copy."

A completely functional PROXI processor-projector has been constructed for study and demonstration purposes. This equipment is shown in Fig. 8. Selenium plates measuring 3 by 3 in. are stored in a magazine, charged, exposed to a simulated cathode-ray-tube presentation, developed, and displayed on demand on the 15 by 15-in. rear projection screen. The access time—i.e., the interval required between the termination of exposure and the beginning of display—is approximately 1.5 sec. The equipment is designed to process only high-contrast line-type input, but could be readily provided with a continuous-tone capability. Screen brightness is approximately 100 ft-L with a 750-w incandescent projection lamp in the optical system. The convenient size of the xerographic plates makes for ease in storage and handling.

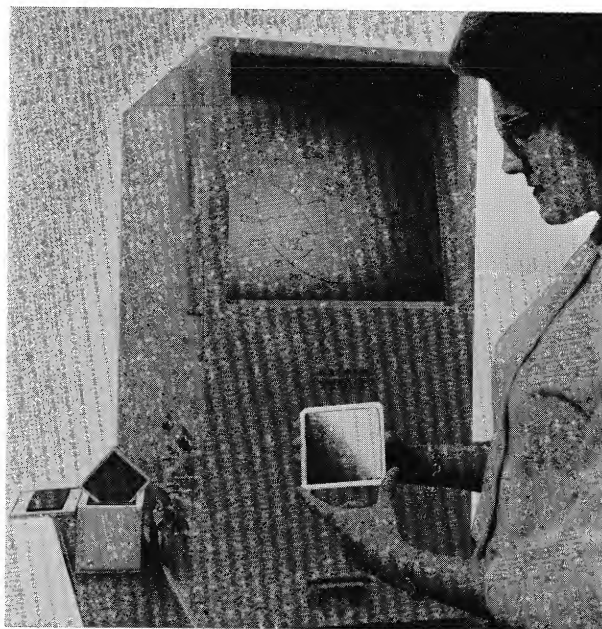


Fig. 8. PROXI processor-projector equipment.

Large Screen Projection

The screen size and brightness for a PROXI display of the type described are limited by the characteristics of the selenium photoconductor. Exposure to high light levels is necessary during the projection step, and although xerographic plates can be manufactured in such a way that their behavior is reproducible from cycle to cycle despite this exposure, there is, nevertheless, an upper limit of exposure which plates can tolerate. In view of these limitations, the PROXI systems which have been described are not suitable for making large-screen bright displays for viewing by large audiences.

However, it is possible to overcome these limitations and permit large-screen displays having size and brightness characteristics limited only by optical systems and light sources. These systems use an additional transfer step for the creation of a transparency for projection in a conventional optical system. Access times are not as short as for the xerographic plate PROXI systems, but the additional time required for the extra transfer step can be of the order of 1 sec, depending on the configuration, giving a bright display with a total access time of about 2 sec.

The powder image formed on the surface of a

xerographic plate can be transferred by electrostatic techniques to many types of insulating surfaces, including transparent plastic sheets. Since the operation can be accomplished in a very short time, it is practical to produce a transparency and advance it quickly into the gate of a conventional projection system for large-screen display. Following transfer, the xerographic plate can be brushed to clean the surface, making it ready for re-use; and to reduce the operating costs of such a machine still further, the transparent medium can also be cleaned and re-used.

The transparency large-screen projection system is adaptable to any of the recording and display arrangements described previously, and can be used in any application where the selenium plate PROXI technique is used. Somewhat longer access times and increased mechanical requirements characterize the system in comparison with the selenium plate PROXI method.

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